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History of the East Point monsoon forest

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Abstract

The 135-hectare East Point Reserve, much of which forms a peninsula projecting into the Beagle Gulf from the city of Darwin, contains a significant remnant of coastal monsoon forest and is abutted in part by mangroves. Historical evidence suggests that monsoon forest once occupied almost all the peninsula, whereas the remnant now occupies 20% of it. Almost half the forest loss occurred prior to 1945 associated with use of the peninsula by the Australian military. The other half was cleared for a golf course and other purposes that we could not identify between 1945 and 1963, mostly between 1955 and 1963. Cyclone Tracy inflicted severe damage to the forest in 1974 but most tree species resprouted. The mangrove stand on the north side of the base of the peninsula has retreated coastward, thickened and extended westward, whilst a smaller stand on the southern side was cleared and has almost disappeared. Since taking over management of the area in 1984, Darwin City Council has revegetated about 20% of the peninsula. Agile Wallabies *Macropus agilis* present in the Reserve proliferated during the 1980s, damaging remnant forest and replantings, but the population returned to much lower densities during the 1990s following closure of most watering points. Significant on-going management issues for the forest include the cost of further revegetation, and weed control. Invasion of remnant forest by Poinciana *Delonix regia*, an attractive non-native tree, may prove to be a controversial management issue in the future.

Introduction

East Point Reserve is an iconic part of the city of Darwin with natural, historical and recreational values. It features prominently in the experience of residents and visitors to Darwin. Much of the reserve's 135 ha is a peninsula, supporting a regionally significant remnant of the coastal monsoon forest which once covered most of the peninsula (Panton 1993). Since 1984, Darwin City Council has undertaken extensive revegetation, the aim being to restore majority coverage of monsoon forest as patches embedded in open areas used for recreation and for grazing by Agile Wallabies *Macropus agilis* (Clouston 2000).

East Point peninsula (12°24'30"S, 130°50'E) (Figure 1) projects *c.* 2.5 km into the Beagle Gulf from a base 6 km north of the Darwin CBD. It comprises a more or less flat, lateritic plateau to a maximum altitude of 11.2 m above sea-level, surrounded for

the most part by low cliffs (Clouston 2000). The isthmus – the current site of Lake Alexander – was a low-lying, swampy flat with coastal sand-dunes on either side while the north side, near the current Spot-On Marine, comprised chenier (coralline sand) (Clouston 2000). The peninsula is well-drained with no natural permanent water. A well dug to 27 m in 1932 contained only salt water (Dermoudy & Cook 1991). The climate is monsoonal tropical as for Darwin, with a mean annual rainfall of approximately 1,700 mm falling predominantly between November and April, and with high temperatures (daily maxima mostly >30°C) throughout the year.

Figure 1. East Point, aerial photograph from 1943, when the military were active on the peninsula; Dudley Point in the south-west is labelled (north is approx. to top of photo). The heavy black line at the base of the peninsula marks the boundary of the area of monsoon forest in 1941 and only areas beyond this line were included in the quantitative analysis of change in forest cover. © Northern Territory of Australia.

East Point peninsula was a military reserve from 1932 to 1963, was managed by the East Point Reserve Trust for recreation from 1964 to 1984, and has been managed by Darwin City Council since then (Griffiths *et al.* 2005).

As background to a field study of the success of regeneration in promoting natural dispersal of monsoon forest plants, we compiled historical information on the vegetation, which is presented here. Our main aim is to document the causes and timing of loss of monsoon forest vegetation and the nature and timing of revegetation.

Methods

We examined aerial photographs of the entire peninsula taken in 1941, 1943, 1945, 1955, 1963, 1974, 1985, 1991, 2002. Three of these (1943, 1974, 2002) are presented here, and a sequence of five (1941, 1974, 1985, 1991, 2002) were reproduced in Griffiths *et al.* (2005). We spoke with parks and gardens staff of Darwin City Council, and to Audrey and Stan Kennon who were members of the Darwin Golf Club from soon after it began operating in the East Point area in 1930 until after it moved elsewhere in 1974 (James 1980a). We also consulted a range of published and archival material and a number of other longer-term residents of Darwin.

For quantitative analysis, we defined East Point as the area west of the line shown in Figure 1, an area of *c.* 105 ha. The boundary line is just beyond where Lake Alexander is now. We chose this line as it was the eastern limit of monsoon forest in the first aerial photograph, taken in 1941. For areas outside this we could only have guessed at the nature of the original vegetation. Aerial photographs were georectified and a grid of points imposed at a field scale of 25 m intervals (1,798 points). For each image, the vegetation at each point was classified as monsoon forest, regeneration, or cleared. Apparent natural infilling or marginal creep of the monsoon forest was included as monsoon forest. Regeneration was only counted if it had a more or less closed canopy, as early-stage regeneration could not be consistently distinguished from grassland. Scattered trees and plantations not associated with revegetation (for example, trees around the military museum and historical relicts) were classified as cleared. The area of vegetation patches was estimated from the number of grid points centred within each.

Original vegetation

There is no detailed record of the nature of the original vegetation, but there is no reason to doubt the interpretation of Panton (1993) that most of the peninsula was originally covered by "monsoon rainforest". Archival images dating back to 1890 show monsoon forest (Figure 2). Aerial photographs taken during World War II when there was much more extensive vegetation cover than at present show no substantial variation in the appearance of the canopy (Figure 1), suggesting that nearly all the original vegetation of the plateau was the same as that of the current remnant monsoon forest. The rather uniform geology, soils and drainage across the plateau also provide a sensible ecological basis for this interpretation.

Figure 2. Archival images of the East Point road, Darwin NT, showing vine-thicket vegetation: A, B. *c.* 1890 (Will Barnes); C. *c.* 1900 (photographer unknown); D. 1934 (photographer unknown). A-C reproduced with permission from the State Library of South Australia (A - catalogue number B 53790; B - B 53812; C - PRG 2801/1/379); D reproduced courtesy of Australian War Memorial.

Based on an extensive floristic survey of the main remnant forest patch (Franklin & Lawes, unpubl. data), the forest belongs to Group 9 of Russell-Smith (1991) – "semi-deciduous rain forests and vine thickets associated with a variety of well to excessively drained coastal and subcoastal landforms" – and more specifically to the sub-coastal sub-group typical of slumping, lateritic coastal cliffs. This vegetation contains a great diversity of tree, shrub and vine-thicket species and cannot be simply characterised by a few of them, though we note a particular prevalence of Grey Boxwood *Drypetes deplanchei*, Tuckeroo *Cupaniopsis anacardioides*, *Miliusa brahei*, Strychnine Tree *Strychnos lucida*, *Tarenna pentamera* and *Antiaris toxicaria*.

A photo taken *c.* 1915 (photographer unknown, http://www.territorystories.nt.gov.au /handle/10070/7451, accessed 2 Sept. 2009) shows *Casuarina* trees growing on top of the coastal cliff. It appears to have been taken from Dudley Point (Figure 1) facing north. The trees are presumably Horsetail Oak *Casuarina equisetifolia*, also known as Coastal She-oak, a common littoral tree around Darwin and present at the site to this day.

Aerial photographs from World War II (e.g. Figure 1) show an extensive band of mangal (mangrove forest or shrubland) along the north shore of the isthmus extending about one-third of the way along the peninsula, and a smaller band on the southern shore near the base of the peninsula.

Clearing the vine-thicket (1932-1963)

The Australian military was evidently the first occupant to substantially modify the vegetation of East Point. Military construction commenced in 1932 and peaked from 1939 to 1943 (Dermoudy & Cook 1991). Forest cover in 1941 (the date of the earliest aerial photograph available to us – it is of poor quality) was 80%, declining to 61% by the end of World War II (Figure 3). In 1941, cleared areas were associated with military buildings and road easements. Buildings were concentrated in three areas: the north-west section near the current military museum and historical relicts; at Dudley Point; and on the south coast near the current site of Peewee's restaurant, as also illustrated in the 1943 photograph (Figure 1). By 1943, a number of areas had been cleared near the base of the peninsula that were associated neither with buildings nor roads. Between 1943 and 1945, clearing was mainly associated with what appears to be a small racecourse.

Stocker (1966) described how monsoon forest disturbed by military activities at East Point was subsequently burnt annually, converting it to a grassy woodland and eliminating all fire-sensitive monsoon forest species. The 1941 aerial photograph shows what appears to be about two hectares of shrubland around the military installations in the north-west of the peninsula – clearly contrasting with the monsoon forest – which in 1943 appears to be grassland; we interpret this as corresponding with Stocker's description.

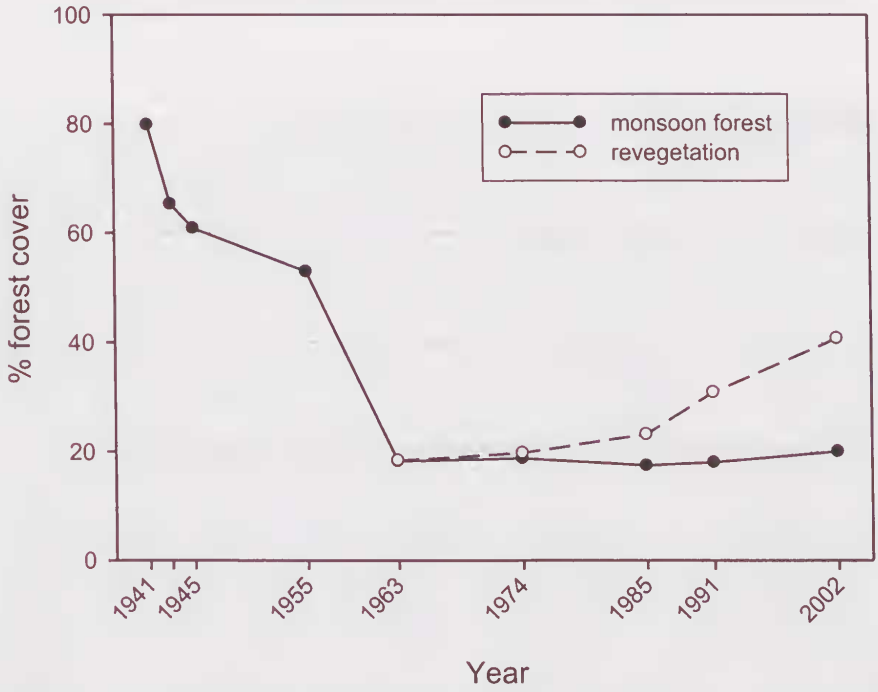

Figure 3. Timeline of forest clearing and revegetation at East Point, Darwin NT, based on eight aerial photographs.

The Darwin Golf Club began operations in 1930 in the vicinity of the Fannie Bay Gaol, being moved to the East Point isthmus near the current Lake Alexander in 1934 to make way for an expansion of the "Ross Smith airstrip ... for the Melbourne air race" (James 1980b). Clearing of the area defined for this study commenced after World War II, the 1955 image showing four holes reaching from the current site of Lake Alexander along the northern side of the Peninsula for about half its length, resulting in the loss of a further 8% of the peninsula forest. Between 1955 and 1963, the course was restructured and nine holes built on the peninsula, reaching from the current site of Lake Alexander to the historical relicts near the current military museum. This involved the clearing of all remaining monsoon forest on the northern third of the peninsula. In 1974 (Figure 4), the golf course was closed and the Club moved to its current site at Marrara.

The central part of the peninsula was also cleared between 1955 and 1963, but we have been unable to ascertain by whom or for what purpose. The combination of this

and clearing for the golf course between 1955 and 1963 resulted in loss of forest cover over 34% of the peninsula.

Figure 4. East Point, Darwin NT, aerial photograph from 1974, with the two remnant patches of monsoon forest numbered. This was the year the golf course closed and a few months before Cyclone Tracy. We interpret the vegetation patch in the centre as long grass prior to or in the very early stages of forest regeneration.

Two remnant patches of monsoon forest remained in 1974 (Figure 4). The main patch, extending along almost the entire southern margin of the peninsula and on either side of the main access road, had an area of *c.* 19.7 ha, whilst patch 2 covered *c.* 1.1 ha. These patches remain (2009) and indeed have expanded in places around the margins (Figures 3, 5), though patch 1 has been subject to minor further disturbance along the south coast and patch 2 is heavily disturbed by grazing horses (DCF pers. obs. 25 August 2009).

Revegetation

The four major areas of revegetation present in 2002 (numbered in Figure 5) have individual histories.

Figure 5. East Point, Darwin NT, aerial photograph from 2002. Patches of revegetated forest in the centre of the peninsula are scarcely distinguishable from the original monsoon forest. Note that Lake Alexander has been built. The canopy along the road through the main original patch monsoon forest is smooth; we believe this to be Poinciana *Delonix regia*. © Northern Territory of Australia.

Patch 1 (3.3 ha) was revegetated by the Northern Territory Government (Stan Kennon pers. comm.). In 1974 (Figure 4) it was already evident though lacking a canopy and with no more than several remnant trees; we interpret this as unmown grass prior to or soon after planting. This interpretation matches well with statements by Darwin City Council staff that planting took place about ten years prior to 1984. They also stated that the plantings were not watered. The patch had a reasonably well-formed canopy in 1985 and a well-formed canopy by 1991.

Patch 2 (0.5 ha; Figure 5) had its nucleus around original trees, which examination on 25 August 2009 suggests may have been *Acacia auriculiformis*. Darwin City Council staff report that it was replanted by (the then) Northern Territory University before

Darwin City Council took over management of the Reserve in 1984. It had a well-formed canopy in 1985.

Darwin City Council took over management of East Point Reserve in 1984 and commenced an ambitious revegetation program in 1985 – patches 3a, b & c (16.6 ha; Figure 5). Scattered trees are evident in the area prior to planting, though many fewer in 1985 than in 1974. Darwin City Council staff advised that many of the remnant trees were *Maranthes corymbosa*, several of which remained until at least 2008 and have been placed on the register of significant trees. Several planted African Mahoganies *Khaya senegalensis* were still there in 2008. *Dodonaea platyptera* (a shrub) and *Cupaniopsis anarcardioides* (a small tree) also persisted at the site.

Revegetation of patch 3 commenced with the area being ripped in a spiral line with 5 m increments using a large bulldozer. A water main was installed, seven irrigation points established, and seedlings planted at 5 m intervals along the spirals. Species planted in 1985 were: *Maranthes corymbosa*, Yellow Flame Tree *Peltophorum pterocarpum*, Banyan *Ficus virens*, Milkwood *Alstonia actinophylla*, Indian Siris *Albizia lebbeck* and Darwin Black Wattle *Acacia auriculiformis*, and possibly also Damson *Terminalia microcarpa* and Red Condoo *Mimusops elengi*. This selection was based on a combination of local occurrence and availability in a local nursery (Darwin Plant Wholesalers at Lambells Lagoon). Many of these plantings were fenced with individual tree guards for protection against browsing Agile Wallabies *Macropus agilis*.

In 1990, a fire burnt most of patch 3c and part of 3b. Its effect in thinning the incipient canopy is clearly evident in the 1991 aerial photograph, but has disappeared by 2002 (Figure 5). It was reported to us as burning 13 ha (this figure presumably includes grassland); our estimate from the 1991 photo is that 6.8 ha of revegetation patch 3 was burnt.

Replacement plantings took place in the early 1990s in collaboration with Greening Australia. These were of the same species and within tree guards, though Agile Wallabies were often able to reach through these. At this stage, the area between the guards was slashed each year, and it was not until soon after 1994 that slashing ceased so that natural regeneration could occur (Simon Stirrat pers. comm.).

Three major weeds proliferated with the regeneration and were subject to control measures: Perennial Mission Grass *Pennisetum polystachion*, Gamba Grass *Andropogon gayanus* and the scrambling shrub Lantana *Lantana camara*. Following an intense campaign to control Lantana patches in forest gaps (*c.* 2003-05; Jamie Lewis pers. comm.), infill planting of these gaps commenced in about 2005. Plantings were from seed and cuttings collected at East Point and grown in the Council nursery, and also of East Point species provided by Greening Australia but potentially sourced elsewhere in the Top End. All these plantings remain staked as at 2008. Use of herbicides and machinery during the Lantana campaign (and during other weed control) impacted severely on the seedling bank in affected areas. Canopy closure has

now largely excluded the three weed species, except around the margins where control is on-going.

The narrow band of vine-thicket along the north coast of the peninsula (patch 4, 4.1 ha; Figure 5), much of which is growing on coralline sand, was virtually absent in 1974 but for some trees or shrubs at the eastern end – in the vicinity of the present mangrove board walk. The eastern end shows substantial thickening in the 1985 aerial photograph, whereas the western end began to develop substantially only later, and notably between 1991 and 2002. It has, for the most part, been self-sown, but with supplementary plantings by Darwin City Council at the eastern end.

The tiny (*c.* 0.1 ha) patch 5 was present and apparently well-developed in 1974 but absent in 1963. In March 2008, a planting of 1,400 trees formed another patch. This comprises *c.* 1 ha and lies to the immediate west of patch 3a (Figure 5), between it and the road near the military museum.

Mangroves

The small mangrove patch on the southern side of the base of the peninsula was completely cleared by Water Resources in *c.* 1964-65, the few remaining trees being regrowth (Helen Haritos pers. comm.). This report is consistent with the aerial photograph record (e.g. Figures 1, 4 and 5) which shows the patch intact up until 1963 but virtually absent in 1974, with growth of a few trees since then. The aerial photograph sequence also suggests substantial change to the more extensive mangrove communities on the northern side, with shoreward retreat, considerable thickening, and extension westwards. Major changes took place between 1974 and 1985.

Cyclone Tracy

Tropical Cyclone Tracy struck Darwin on Christmas Day in 1974 – the year the Darwin Golf Club moved from East Point to Marrara. Stocker (1976) provided photographs and some description of damage to native vegetation around Darwin based on an inspection seven weeks later. Two photos of the East Point monsoon forest (Stocker 1976; page 28) show extensive loss of crowns and considerable damage to branches but also vigorous regeneration of most crowns. Stocker noted that the monsoon forest at East Point was damaged less than other monsoon forests notwithstanding its exposed position.

Fox (1980) evaluated the severity of damage and regeneration modes of monsoon forest species at East Point in ten 20 x 20 m plots within a few years after the cyclone, though no survey date is given. Most species resprouted, but a few (particularly *Alstonia actinophylla*) did not. The notably very few seedlings were mainly of *Acacia auriculiformis*, and Fox argued that emergent seedlings may have been suppressed by prolific growth of vines.

Agile Wallabies

As documented in detail by Griffiths *et al.* (2005), the population of Agile Wallabies at East Point exploded to a peak of *c.* 2,000 in the late 1980s from historical levels of *c.* 150 to 400. The increase is believed to be the product of provision of watering troughs in the period 1980 to 1984, and of watering points by Darwin City Council in the mid 1980s for their revegetation program. The mechanism for demographic adjustment is likely to have been improved juvenile survival during the nutritionally-harsh dry season (Stirrat 2003, 2008). As well as generating a problem with collisions on the road through East Point, high densities of Agile Wallabies destroyed many plantings and were perceived to be a threat to natural regeneration of the remnant monsoon forest. Stirrat (2002) found that Agile Wallabies at East Point consumed mainly grasses and other herbs during the wet season, but consumed a much wider range of foods including browse, leaf litter and roots during the dry season. Using exclosure experiments, Stirrat (2000) found that Agile Wallabies suppressed survival of monsoon forest seedlings, severely depleted the leaf litter layer and disturbed the soil. However, the wallabies browsed only a few monsoon forest species "notably the vines *Capparis sepiaria* and *Flagellaria indica*" and the depressed survival of seedlings may have been due to indirect effects such as dehydration following the loss of leaf litter.

The supply of water available to Agile Wallabies was progressively reduced to just a few troughs by 1995 (Griffiths *et al.* 2005). The population declined progressively through the 1990s and by 2000 had returned to what are believed to be historical levels of several hundred.

Discussion

Reduction of the East Point monsoon forest to *c.* 20% of its original area is attributable to the military and to the Darwin Golf Club, though we have been unable to identify the agent responsible for *c.* 22% of the clearing. Both activities occurred in an era when little value was placed on native vegetation in general and monsoon forest in particular, despite the latter having only scattered occurrence in the Darwin region (Panton 1993) and elsewhere in the Top End (Russell-Smith & Dunlop 1987).

The loss of monsoon forest for expansion of the golf course after 1955 is particularly tragic and a testament to a lack of forward planning, given that the golf course was closed less than 20 years later in 1974. It was reported (unpublished documents and several personal communications) that the golf course was moved to Marrara because of a government plan to build a road (the "Palmerston Freeway") connecting Fannie Bay to Nightcliff through the golf course at the base of the peninsula, presumably across the mouth of Ludmilla Creek. The plan was subsequently shelved, perhaps because Cyclone Tracy demonstrated the vulnerability of mangrove areas, and Dick Ward Drive appears to have been developed as an alternative route. Another

suggestion put to us was that the decision was a political move to encourage the development of Marrara as a suburb. The two explanations are potentially compatible.

Overt human interference was responsible for the near-complete loss of the mangrove patch on the southern side of the peninsula. We have been unable to determine why the patch was cleared by Water Resources, but it was directly adjacent to a water testing laboratory established and run by that organisation for at least the period 1966 to 1974 (H. Haritos, pers. comm.). We can only speculate as to the causes of the increase and movement of the mangroves on the northern side. This patch is close to the mouth of Ludmilla Creek and may be subject to substrate instability associated with freshwater outflows. Urbanisation of the creek's catchment could have increased storm-water and nutrient run-off. Freshwater flows are known to improve mangrove growth (Semeniuk 1983). A fertiliser effect from the Ludmilla Wastewater Treatment Plant which discharges off the north coast of East Point, is also possible. Parallel increase and shoreward movement of mangroves occurred around and to the east of Buffalo Creek (12 km north-east of East Point) between 1974 and 2004; the rate of change was doubled in a mangrove swamp impacted by changes to run-off and construction of a sewage treatment plant, compared to a nearby unaffected swamp (Williamson *et al.* in press).

Revegetation work, undertaken mainly by Darwin City Council, demonstrates long-term commitment to the future of the Reserve as a historic, conservation, recreation and tourist resource, backed by a plan of management (Clouston 2000). This work has not been without problems and challenges; fire, weeds and proliferation of Agile Wallabies have all proven to be substantial management issues. Weed management and further revegetation will require substantial resources in the future. Notwithstanding, Darwin City Council (mainly) and other agents have succeeded in doubling the area of monsoon forest on the peninsula from its low point in 1974. We are currently undertaking an assessment of the extent to which this revegetation has rejuvenated forest ecosystem structure and processes. However, even a rather cursory examination confirms success in creating a closed canopy (Figure 6), encouraging natural regeneration, and creating habitat for monsoon forest specialists such as the Rainbow Pitta *Pitta iris*, a litter-foraging bird.

The great importance of peri-urban habitat patches such as these as refuges for fauna that cannot persist in the greater landscape matrix, perhaps due to prevailing fire regimes, was demonstrated by Price *et al.* (2005). Despite the strong argument that all patches of monsoon forest in the Northern Territory should be maintained because they are inter-dependent, such that the loss of patches may reverberate more widely through the system (Price *et al.* 1995; Bach & Price 2005), a number of monsoon forest patches remain under significant pressure due to development, weeds and fire regimes in particular (Russell-Smith & Bowman 1992; Panton 1993).

Figure 6. The largest patch of revegetated monsoon forest (patch 3a in Figure 5) now has a closed canopy and much natural regeneration, and in places resembles an undisturbed monsoon forest. A. original monsoon forest remnant on left, revegetation patch 3a on right, looking westward; B., C. interior of patch 3a. Photographs taken 13 September 2009. (D. Franklin)

As resources become available, Darwin City Council intends extending the landscape design already in place, in which patches of monsoon forest are embedded in a grassland matrix, by creating further patches.

A significant and potentially politically-fraught management issue for the future is the invasion of otherwise intact monsoon forest by the non-native Poinciana *Delonix regia* (Toohey 2001). This attractive tree provides mass displays of red flowers during October and November. It is abundant along the southern margin of the main patch of remnant monsoon forest and our observations suggest that is expanding into the forest.

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The woody vine Opilia *Opilia amentacea* is common in the East Point monsoon forest. (Don Franklin)